Geometric and Electrochemical Characteristics of NMC Electrodes with Different Calendering Conditions.

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The energy and power capabilities of Li ion batteries (LIBs) have been considered critical factors to determine the commercial values of the LIB powered applications. Many efforts have been done to improve the energy density and rate capability of LIBs. In addition to intrinsic material properties of anode and cathode active materials, the structure of electrode at micro and nano scales also plays a critical role in determining the energy density and rate capability of a LIB [1-3]. Calendering is a process in battery manufacturing to lower the porosity of the electrode and increase electrical contact. Increased calendering can increase the packing density of active materials in LIB electrodes, thereby increasing the volumetric energy density. The specific energy density is also increased by calendering via decreasing the percentage of inactive materials, such as current collector and separator. However, higher fraction of active materials in LIB electrodes can change electrodes' structural properties significantly, such as porosity, specific surface area, pore size distribution and tortuosity [4].

To this end, there are few reports on the geometric characteristics and their impact on the electrochemical performance of LIB electrodes with different calendering conditions due to the inhomogeneity, complexity, and three-dimensional (3D) nature of the electrode's microstructure [5-6]. Recently, porous electrode microstructures have been reconstructed by advanced tomography techniques such as X-ray nano-computed tomography (nano-CT) and focused ion beam scanning electron microscope (FIB-SEM)[7-8]. The reconstructed microstructures have been employed to investigate the geometric characteristics and spatial inhomogeneity of porous electrodes. In this study, we investigated real 3D $Li[Ni_{1/3}Mn_{1/3}Co_{1/3}]O_2$ (NMC) electrode microstructures under different calendering conditions and the effect of calendering on the performance of LIBs[4].

To investigate geometric characteristics of porous microstructures, cathode electrodes were fabricated from a 94:3:3 (weight %) mixture of NMC, PVDF, and super-P carbon black. To change the calendering condition, initial thickness of the electrodes was set 50 µm, 80um, 90um, 100um. Then all electrodes were pressed down to 50 µm by using a rolling press machine. A synchrotron X-ray nano-CT at the Advanced Photon Source of Argonne National Lab was employed to obtain morphological data of the electrodes, with voxel size of $58.2 \times 58.2 \times 58.2$ nm^3. The morphology data sets were quantitatively analyzed to characterize their geometric properties. The geometric analysis showed that high packing density can result in smaller pore size and more uniform pore size distribution. The specific surface area and tortuosity of different electrodes will be reported. The charge/discharge experiments were also conducted for these electrodes. The geometric properties and cell testing results will be analyzed and reported.

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